

5 Deadly Sins and 5 Best Practices of Proposal Writing: *Views of Two ARPA-E Program Directors*

Dane A. Boysen, PhD – Program Director
Ilan Gur, PhD - Program Director & Senior Advisor

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ARPA-E Overview



History of ARPA-E

2006
*Rising Above the
Gathering Storm*
(National Academies)



2007
America
Competes Act

2009-2010
American
Recovery &
Reinvestment Act
(\$400M)



2011
FY2011 Budget
(\$180M)

2012
FY2012 Budget
(\$275M)



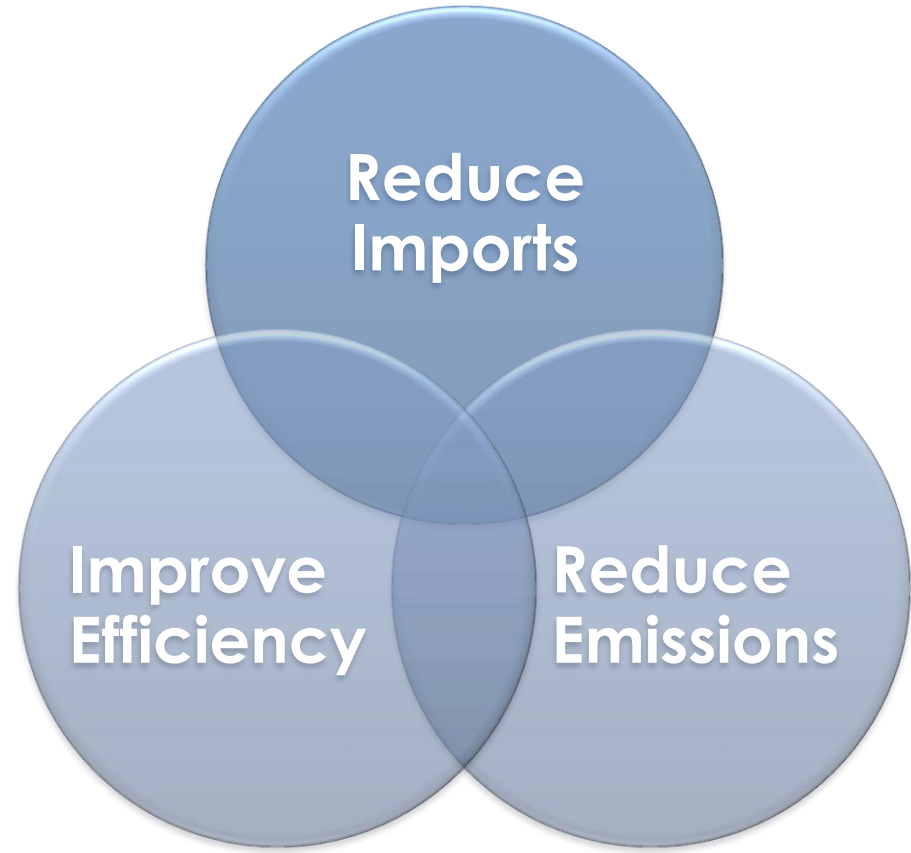
Arun Majumdar
1st Director

The ARPA-E Mission

Catalyze and support the development of transformational, high-impact energy technologies

Ensure America's

- National security
- Economic security
- Energy security
- Technological lead



What makes an ARPA-E program?

1. Impact

- ▶ High impact on ARPA-E mission areas
- ▶ Credible path to market
- ▶ Large commercial application



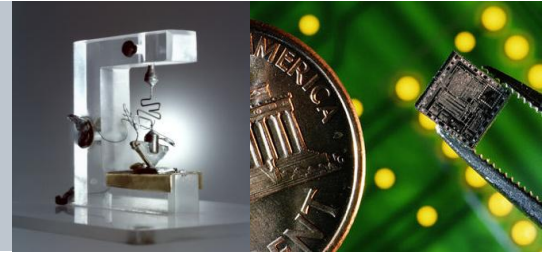
2. Transform

- ▶ Challenges what is possible
- ▶ Disrupts existing learning curves
- ▶ Leaps beyond today's technologies



3. Bridge

- ▶ Translate science into breakthrough technology
- ▶ Not researched or funded elsewhere
- ▶ Catalyzes new interest and investment



4. Team

- ▶ Best-in-class people
- ▶ Cross-disciplinary skill sets
- ▶ Translation oriented



5 Deadly Sins



5 Deadly Sins of an ARPA-E proposal

Thou shall not submit a proposal that is...

1. Insignificant
2. Indistinguishable
3. Incremental
4. Incoherent
5. Indefinite



5 Deadly Sins of an ARPA-E proposal

- **Insignificant:** The proposal does not draw a clear connection showing that a successful project would lead to significant impact on on of ARPA-E's mission areas



5 Deadly Sins of an ARPA-E proposal

- **Insignificant:** The proposal does not draw a clear connection showing that a successful project would lead to **significant impact** on on of ARPA-E's mission areas



Our advanced block copolymer membrane technology will dramatically improve energy efficiency of coffee filtering:

- 10X more energy efficient than state-of-the-art coffee filtration
- Impact over 100 million coffee drinkers in US

5 Deadly Sins of an ARPA-E proposal

- **Insignificant:** The proposal does not draw a clear connection showing that a successful project would lead to significant impact **on one of ARPA-E's mission areas**

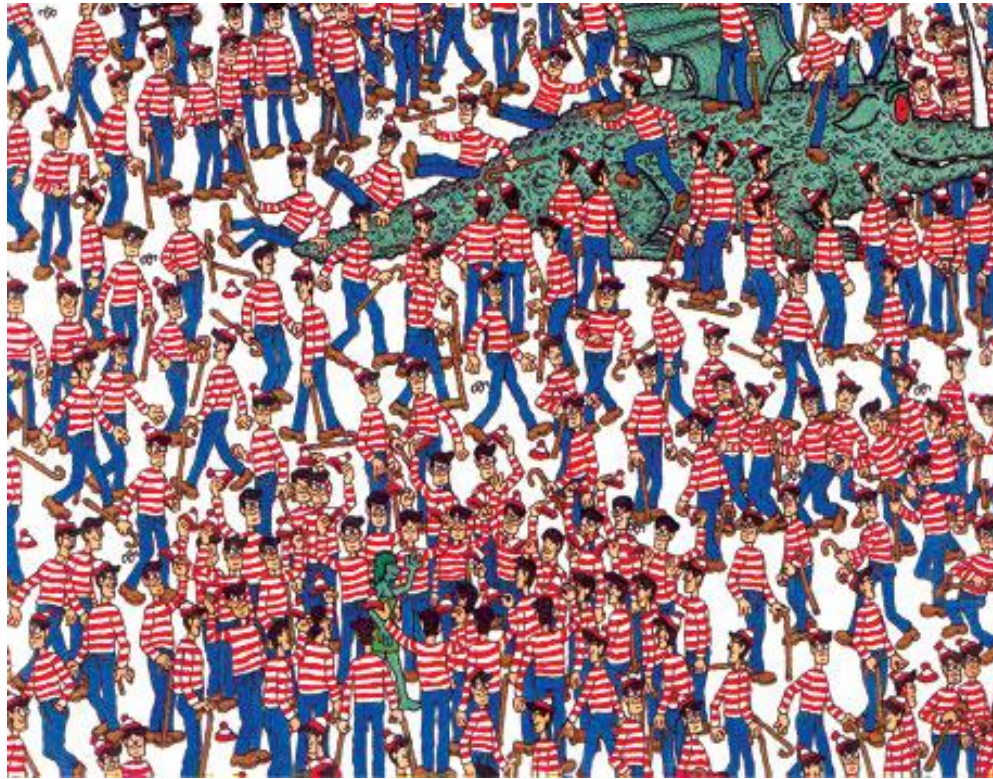
Our novel hydrogel technology will allow for a new generation of super biodegradable diapers:

- Exposing diaper to uv light activates ability to fully dissolve in water in 30 seconds, vs. the 300 year biodegradation time scale of conventional diapers
- Will save ~18 billion diapers from entering US landfills each year



5 Deadly Sins of an ARPA-E proposal

- **Indistinguishable:** The proposal fails to communicate how the proposed approach is innovative and differentiated from commercial or emerging technologies being funded or developed elsewhere.



5 Deadly Sins of an ARPA-E proposal

- **Incremental:** The proposal describes a low-risk approach that seems more like an engineering development project vs. disruptive R&D



5 Deadly Sins of an ARPA-E proposal

- **Incoherent:** The proposal reads as though several disparate sections by different team partners were written independently and "stapled" together -- lacks cohesive vision/teaming



5 Deadly Sin" of an ARPA-E proposal

- **Indefinite:** The proposal generically describes ideas being proposed without any detail on the technology, and/or provides no justifications for the claims that are made.



Next generation vehicle allows for flexible, energy efficient time travel

- Allows for 10X more efficient time travel to any date and place in the history of the universe
- Technology leverages novel proprietary technology from Doc and McFly Industries, Inc.
- Technology has been validated at proof-of-concept scale by D&M Industry advisors, including several nobel laureates



5 Deadly Sin" of an ARPA-E proposal

- **Indefinite:** The proposal generically describes ideas being proposed without any detail on the technology, and/or provides no justifications for the claims that are made.



Next generation vehicle allows for flexible, energy efficient time travel

- Allows for 10X more efficient time travel to any date and place in the history of the universe
- Next generation flux capacitor based on proprietary hafnium alloy is the key enabling technology
- Capacitor placement within metallic vehicle body perturbs the flux dispersal field, allowing smooth passage through the space-time continuum (see references 3-8)
- Time travel requires 1.21 Jigawatt-hours of electrical power, with allows for 10x efficiency gain as validated via the mass/energy balance outlined in Table 3

5 Deadly Sins of an ARPA-E proposal

1. **Insignificant:** The proposal does not draw a clear connection showing that a successful project would lead to significant impact on one of ARPA-E's mission areas
2. **Indistinguishable:** The proposal fails to communicate how the proposed approach is innovative and differentiated from commercial or emerging technologies being funded or developed elsewhere.
3. **Incremental:** The proposal describes a low-risk approach that seems more like an engineering development project vs. disruptive R&D
4. **Incoherent:** The proposal reads as though several disparate sections by different team partners were written independently and "stapled" together -- lacks cohesive vision/teaming
5. **Indefinite:** The proposal generically describes ideas being proposed without any detail on the technology, and/or provides no justifications for the claims that are made.



The 6th Deadly Sin

Thou shall not submit a proposal that is...

INSINCERE

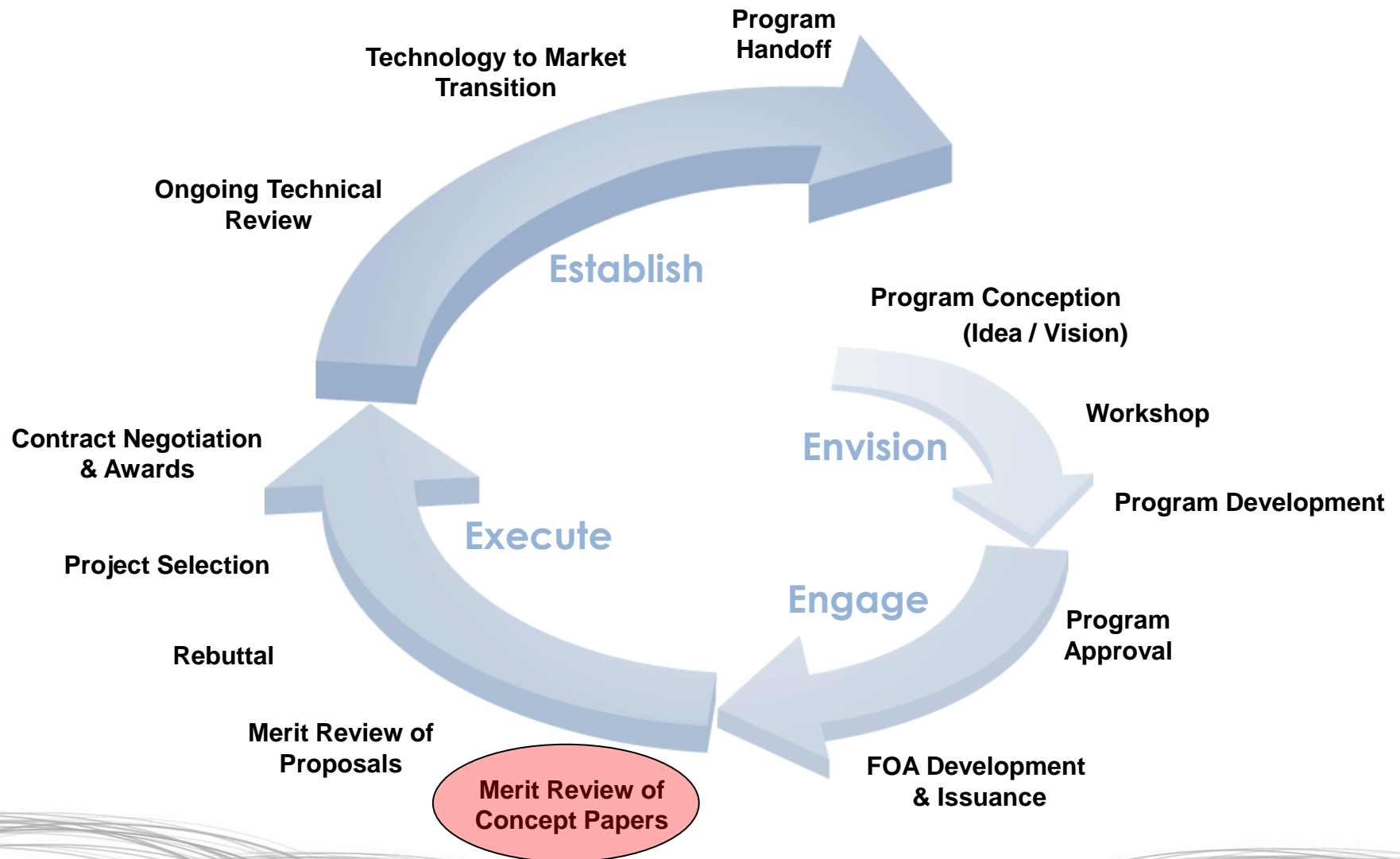


5 Best Practices

Please note that these “Best Practices” are primarily targeted at the Concept Paper stage of the ARPA-E funding application process.



ARPA-E Program Development Cycle



Literature Example

Rechargeable Solid State Fluorine Ion Battery

We propose a rechargeable fluorine ion (F-ion) battery that uses a solid state fluorine ion conductor (e.g. $\text{La}_{0.9}\text{Ba}_{0.1}\text{F}_{2.9}$) with metal fluoride electrodes, such as the Ce// CuF_2 couple. Solid state F-ion batteries with electrodes such as Ce// CuF_2 electrodes have a theoretical energy density of 792 Wh/kg (2.9 V) that compares favorably to state-of-the-art Li-ion batteries such as LiC_6 // CoO_2 at 568 Wh/kg (3.6 V). To date, we have demonstrated that the Ce// BiF_3 electrode couple is rechargeable (Figure 2). Several key challenges remain in demonstrating the viability of a F-ion battery including: 1) decreasing electrolyte resistance losses, 2) increasing electrode material utilizations, and 3) maintaining capacity over long cycle life. In the proposed work these challenges will be addressed by 1) decreasing the electrolyte thickness and doping the electrolyte to increase conductivity, 2) engineering electrode microstructure to better utilize electrode material; and 3) selecting optimal electrode materials for enhanced cyclability.

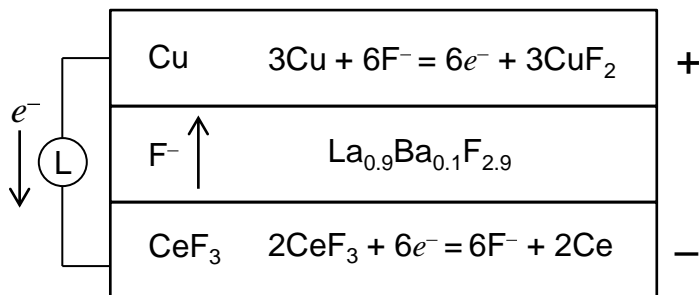


Figure 1. Diagram F-ion battery with Ce// CuF_2 electrodes.

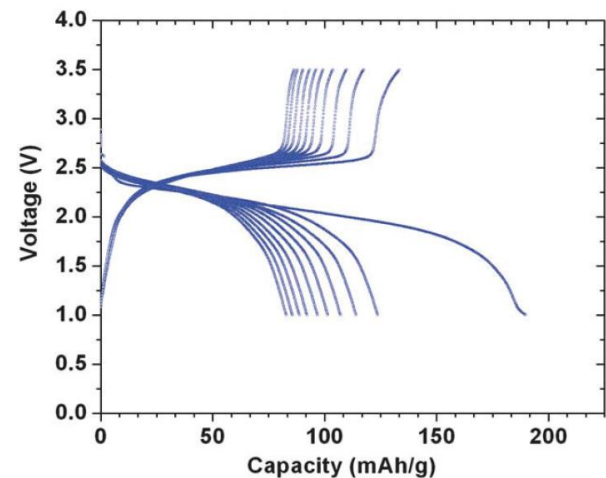


Figure 2. Preliminary charge-discharge cycles at 10 μm^2 and 150 $^\circ\text{C}$ of a Ce// BiF_3 cell.

Reference: MA Reddy, M Fichtner. *J. Mater. Chem.* 21:17059, 2011

5 Best Practices

1. Describe the technological innovation in the first sentence

Rechargeable Solid State Fluorine Ion Battery

We propose a rechargeable fluorine ion (F-ion) battery that uses a solid state fluorine ion conductor (e.g. $\text{La}_{0.9}\text{Ba}_{0.1}\text{F}_{2.9}$) with metal fluoride electrodes, such as the Ce//CuF_2 couple. Solid state F-ion batteries with electrodes such as

couple is rechargeable (Figure 2). Several key challenges remain in demonstrating the viability of a F-ion battery including: 1) decreasing electrolyte resistance losses, 2) increasing electrode material utilizations, and 3) maintaining capacity over long cycle life. In the proposed work these challenges will be addressed by 1) decreasing the electrolyte thickness and doping the electrolyte to increase conductivity, 2) engineering electrode microstructure to better utilize electrode material; and 3) selecting optimal electrode materials for enhanced cyclability.

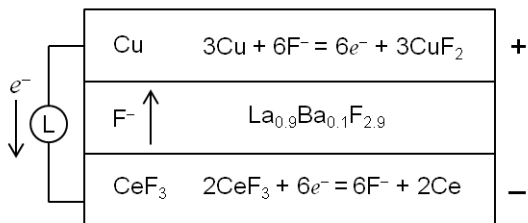


Figure 1. Diagram F-ion battery with Ce//CuF_2 electrodes.

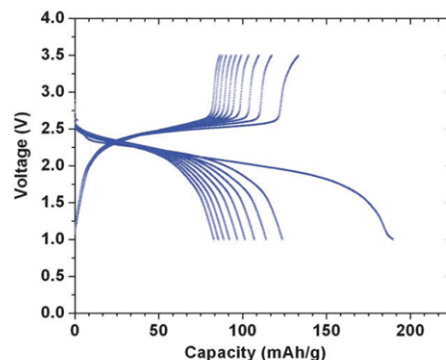


Figure 2. Preliminary charge-discharge cycles at $10 \text{ } \mu\text{m}^2/\text{cm}^2$ and 150°C of a Ce//BiF_3 cell.

Reference: MA Reddy, M Fichtner. *J. Mater. Chem.* 21:17059, 2011

5 Best Practices

2. Provide a visual aid describing technology directly after the first paragraph

Rechargeable Solid State Fluorine Ion Battery

We propose a rechargeable fluorine ion (F-ion) battery that uses a solid state fluorine ion conductor (e.g. $\text{La}_{0.9}\text{Ba}_{0.1}\text{F}_{2.9}$) with metal fluoride electrodes, such as the Ce//CuF₂ couple. Solid state F-ion batteries with electrodes such as Ce//CuF₂ electrodes have a theoretical energy density of 792 Wh/kg (2.9 V) that compares favorably to state-of-the-art Li-ion batteries such as LiC₆//CoO₂ at 568 Wh/kg (3.6 V). To date, we have demonstrated that the Ce//BiF₃ electrode couple is rechargeable (Figure 2). Several key challenges remain in demonstrating the viability of a F-ion battery including: 1) decreasing electrolyte resistance losses, 2) increasing electrode material utilizations, and 3) maintaining capacity over long cycle life. In the proposed work these challenges will be addressed by 1) decreasing the electrolyte resistance, 2) increasing the electrode material utilization, and 3) optimizing the electrode microstructure to better utilize the electrolyte and improve cyclability.

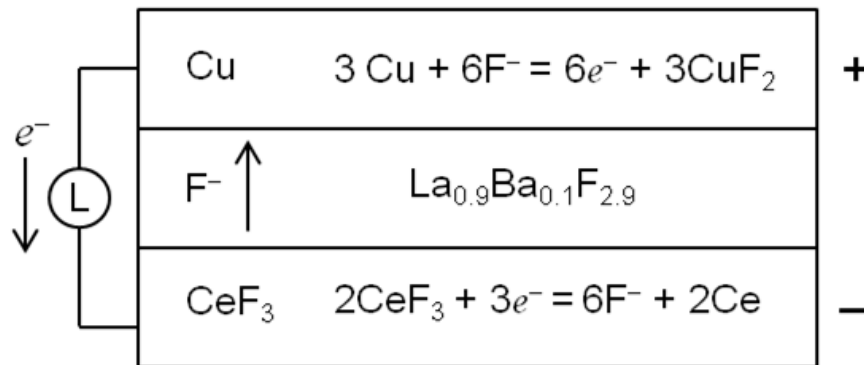


Figure 1. Diagram F-ion battery with Ce//CuF₂ electrodes.

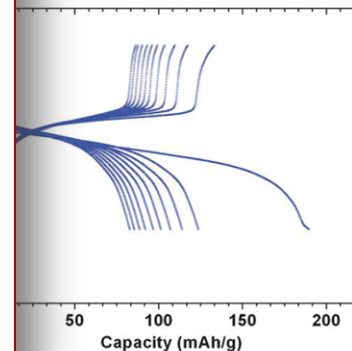


Figure 2. Preliminary charge-discharge cycles at 10 150 °C of a Ce//BiF₃ cell.

5 Best Practices

3. Back-up claims with data or strong scientific rationale

Rechargeable Solid State Fluorine Ion Battery

We propose a rechargeable fluorine ion (F-ion) battery that uses a solid state fluorine ion conductor (e.g. $\text{La}_{0.9}\text{Ba}_{0.1}\text{F}_{2.9}$) with metal fluoride electrodes, such as the Ce//CuF_2 couple. Solid state F-ion batteries with electrodes such as Ce//CuF_2 electrodes have a theoretical energy density of 792 Wh/kg (2.9 V) that compares favorably to state-of-the-art Li-ion batteries such as $\text{LiC}_6\text{//CoO}_2$ at 569 Wh/kg. The Ce//CuF_2 couple is rechargeable (Figure 2). Several strategies are being explored, including: 1) decreasing electrolyte resistance; 2) increasing capacity over long cycle life. In the proposed design, we are exploring: 1) decreasing electrolyte thickness and doping the electrolyte to increase ionic conductivity; 2) selecting optimal electrode material; and 3) selecting optimal electrolyte material.

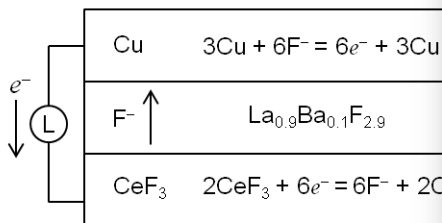


Figure 1. Diagram F-ion battery with Ce//CuF_2

Reference: MA Reddy, M Fichtner, *J. Mater. Chem.* 21:11

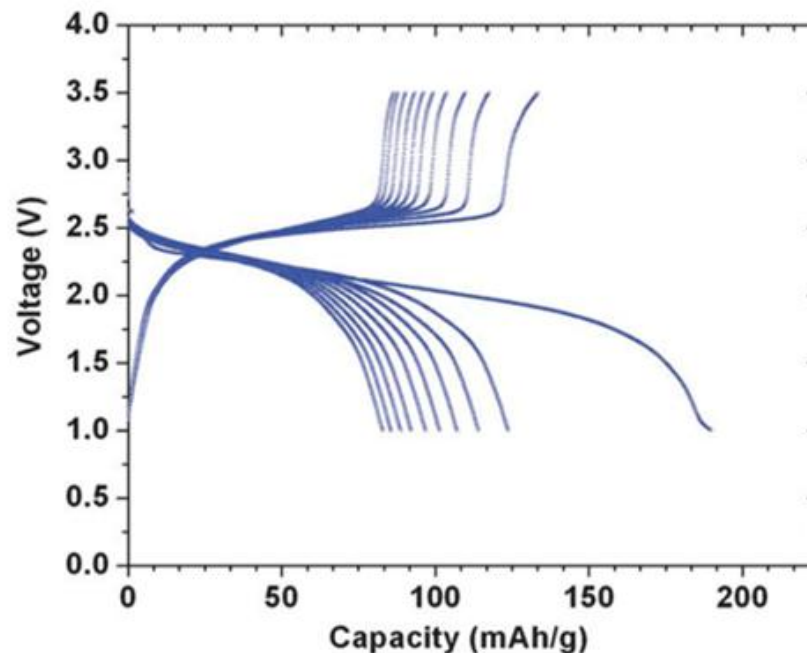


Figure 2. Preliminary charge-discharge cycles at 10 $\mu\text{m}^2/\text{cm}^2$ and 150 $^\circ\text{C}$ of a Ce//BiF_3 cell.

5 Best Practices

4. Compare proposed technology to the state of art

Rechargeable Solid State Fluorine Ion Battery

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with metal fluoride electrodes, such as the Ce//CuF_2 couple. Solid state F-ion batteries with electrodes such as Ce//CuF_2 electrodes have a theoretical energy density of 792 Wh/kg (2.9 V) that compares favorably to state-of-the-art Li-ion batteries such as $\text{LiC}_6\text{//CoO}_2$ at 568 Wh/kg (3.6 V). To date, we have demonstrated that the Ce//BiF_3 electrode

including 1) decreasing electrolyte thickness, 2) increasing electrode material thickness and 3) maintaining capacity over long cycle life. In the proposed work these challenges will be addressed by 1) decreasing the electrolyte thickness and doping the electrolyte to increase conductivity, 2) engineering electrode microstructure to better utilize electrode material; and 3) selecting optimal electrode materials for enhanced cyclability.

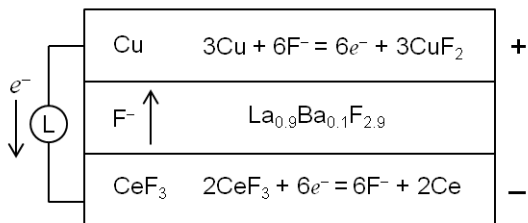


Figure 1. Diagram F-ion battery with Ce//CuF_2 electrodes.

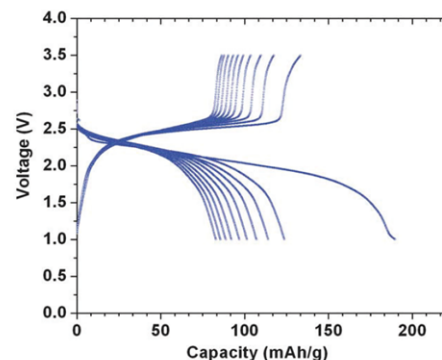


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5 Best Practices

5. Clearly identify the technical challenges and approaches to solving them

Rechargeable Solid State Fluorine Ion Battery

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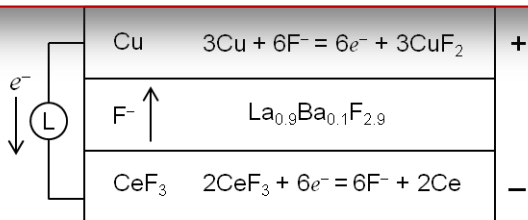


Figure 1. Diagram F-ion battery with Ce//CuF₂ electrodes.

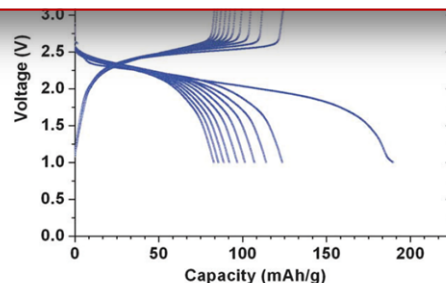


Figure 2. Preliminary charge-discharge cycles at 10 $\mu\text{m}^2/\text{cm}^2$ and 150 $^\circ\text{C}$ of a Ce//BiF₃ cell.

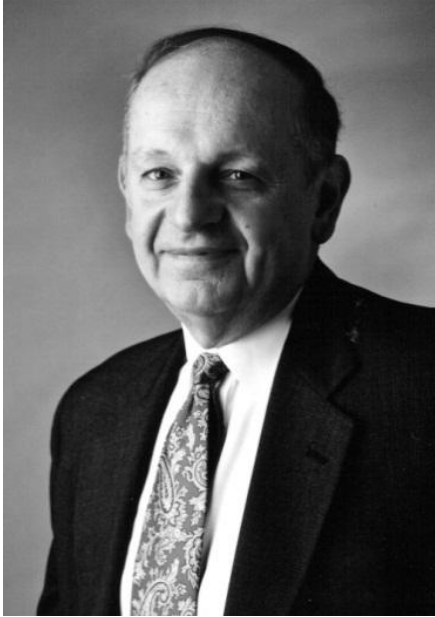
Reference: MA Reddy, M Fichtner. *J. Mater. Chem.* 21:17059, 2011

Summary of Best Practices

1. Describe the technological innovation in the first sentence
2. Provide a visual aid describing technology directly after the first paragraph
3. Back-up claims with data or strong scientific rationale
4. Compare proposed technology to the state of art
5. Clearly identify the technical challenges and approaches to solving them



The Heilmeier Catechism



George H. Heilmeier
DARPA Director (1975-1977)

- What are you trying to do? Articulate your objectives with absolutely no jargon.
- How is it done today, and what are the limits of current practice?
- What's new in your approach and why do you think it will be successful?
- Who cares?
- If you're successful, what difference will it make?
- How much will it cost?
- How long will it take?
- What are the midterm and final “exams” to check for success?



Questions?

Please use the WebEx Q&A box to submit your questions.

